INSTRUCTIONS

1. **ALL WORK MUST BE YOUR OWN.** You may use a foreign language dictionary if necessary.

2. Answer all questions on both the answer sheet (in pencil) **AND** on the test.  
   [Only answers marked on the answer sheet will receive credit.]

3. Make sure your name and section number [in the special code section] are on the answer sheet and then fill in the corresponding spaces below each letter and number.

4. Read everything carefully. If there is anything that you do not understand about any question, ask one of the proctors.

5. **READ ALL OF THE ANSWERS** and choose the **best** answer for each question. There is only **one best answer** for each question. No credit will be given for a question with more than one answer marked.

6. Turn in **both** the answer sheet and this test booklet at the end of the exam.

7. The exam is due when the first bell rings.

Seating: leave at least one open chair between yourself and others.
Some Useful Equations and Conversions

Efficiency = \frac{\text{Useful Energy Out}}{\text{Total Energy In}}

W = F D

F = Ma

F = Mg

\( E_{\text{pot}} = M g h \)

\( E_{\text{kin}} = \frac{1}{2} M v^2 \)

\( G = 6.67 \times 10^{-11} \text{ N m}^2 / \text{kg}^2 \)

\( g = 9.8 \text{ m/s}^2 = 32 \text{ ft/s}^2 \)

1 mile = 5280 feet = 1.609 kilometers

1 ft = 0.305 meters

1 lb = 4.45 N

1 joule = 0.74 foot pounds = 0.24 calorie

1 kilogram = 1000 grams

Distance from the Earth’s center to its surface = 6.37 \times 10^6 \text{ m}

Mass of the Earth = 5.98 \times 10^{24} \text{ kg}

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1. The Mars Pathfinder spacecraft traveled about $3 \times 10^8$ miles to reach Mars. It moved at an average speed of $1.5 \times 10^6$ miles per day. How many days did it take to reach its destination?
   
   a) 20 days
   b) 30 days
   c) 50 days
   d) 200 days
   e) 360 days

2. In class we saw a person riding a bicycle generating the electrical energy required to light a number of 50 watt bulbs. Assume that this person generated 1,200 watts (1,200 joules/sec) and was able to make 4 of the bulbs light. What is the efficiency of this energy conversion?
   
   a) 4%
   b) 12%
   c) 17%
   d) 21%
   e) 48%

3. A 5 pound brick and a 40 pound concrete block are dropped from a cliff at the same time. Neglecting air resistance, which of the following is true?
   
   a) The block will fall faster than the brick because larger objects have a greater gravitational acceleration.
   b) The block will fall faster than the brick because a greater gravitational force is acting on the block than on the brick.
   c) There is a greater gravitational force acting on the block, but it will fall with the same acceleration as the brick.
   d) Both the block and the brick will fall with the same acceleration because the same amount of gravitational force acts on each.
   e) The smaller brick will fall faster because it has less mass to accelerate.

4. Elmo has three toy cars: a rubber band powered car, a battery powered car, and a car which is designed to coast down a hill. What is the energy source for each of these three cars?
   
   a) magnetic, electrical, gravitational
   b) strain, chemical, gravitational
   c) strain, thermal, gravitational
   d) magnetic, chemical, mechanical
   e) radiant, nuclear, mechanical
5. You’re stuck in a sail boat far from shore, and there is no wind. You have a fan that you can turn on. To get back to the shore **AS RAPIDLY AS POSSIBLE**, you should

a) point the fan away from shore and don’t use the sail.
b) open the sail and point the fan at the sail and towards the shore.
c) take down the sail and point the fan towards the shore.
d) open the sail, and point the fan away from the sail and away from shore.
e) just relax and wait for the wind to pick up.

6. The video *Why Physics?* there were a number on things that relate to the study of physics. In the list below which one was **NOT** mentioned in the video?

a) The force of friction between our shoes and the sidewalk allows us to walk without sliding.
b) When shooting a basketball you need to know the correct angle that will result in getting a basket.
c) People who jump from bridges using a parachute rely on air resistance.
d) Hydroelectric dams are used to generate electricity.
e) Physics makes it possible for us to understand the world around us.

7. If Elliott travels in his car on a straight road at 60 miles/hour for 15 minutes, how far does he go?

a) 4 miles
b) 15 miles
c) 20 miles
d) 30 miles
e) 900 miles

8. When driven on a highway, Bob’s car gets 33 miles/gal. If 1 mile = 1.61 kilometers and 1 liter = 0.264 gallons, then what is the mileage of Bob’s car when expressed in kilometers/liter?

a) 5.4 kilometers/liter
b) 14 kilometers/liter
c) 53 kilometers/liter
d) 78 kilometers/liter
e) 201 kilometers/liter
9. You push a box weighing 25 Newtons up the incline shown below. The friction force is 3 Newtons. How much work do you expend?

a) 15 Joules
b) 27 Joules
c) 75 Joules
d) 90 Joules
e) 125 Joules

10. You drive your car at a constant speed of 20 MPH around a circular track. Which statement regarding this activity is TRUE?

a) The car is accelerating.
b) If the diameter of the track decreases, the time it takes to go completely around the track increases.
c) There are no forces on the car.
d) If the diameter of the track increases, the time it takes to go completely around the track decreases.
e) Since the speed of the car is constant, the acceleration of the car is zero.

11. In class we put drops of water in a hollow drill bit and created friction in order to pop a cork from the end of the bit. Assuming the cork shot high into the air, what is the sequence of energy transformations starting with the drill and ending with the cork falling to the floor?

a) thermal, mechanical, thermal, electrical, gravitational, mechanical, thermal
b) electrical, mechanical, thermal, mechanical, gravitational, mechanical, thermal
c) thermal, mechanical, gravitational, mechanical, electrical
d) electrical, radiant, thermal, nuclear, gravitational, mechanical
e) electrical, chemical, thermal, mechanical, gravitational, mechanical, radiant
12. Two spherical balls have their centers-of-mass separated by a distance of 20 meters. One ball has a mass of 60 kilograms and the other has a mass of 40 kilograms. Which statement is CORRECT?

a) The force on the 60 kilogram mass is larger than the force on 40 kilogram mass  
b) The force on the 40 kilogram mass is larger than the force on 60 kilogram mass  
c) The force on the 40 kilogram mass 0.66 times the force on 60 kilogram mass  
d) The force on the 40 kilogram mass 1.5 times as the force on 60 kilogram mass  
e) The force on the 40 kilogram is equal to the force on the 60 kilogram mass

13. Because of air resistance, a skydiver of mass 60 kilograms stops accelerating soon after jumping from the plane. How much upward force is exerted on the skydiver by air resistance at this time?

a) None.  
b) 29 newtons  
c) 59 newtons  
d) 588 newtons  
e) Not enough information is given to be able to answer the question.

14. Tom wants to increase the kinetic energy of a moving ball to 16 times what it has to start with. By what factor must Tom increase the speed of this ball?

a) 2  
b) 4  
c) 8  
d) 16  
e) 32

15. On a balance you find that 3 cubes will balance 1 disc, and 12 discs will balance 1 rod. How many cubes will balance 1 rod?

a) 1/36  
b) 1/4  
c) 4  
d) 15  
e) 36
16. You drop a bowling ball from the roof of a tall building. What is the velocity of the ball after it has fallen for 3 seconds? (Ignore air resistance.)

a) 3 meters per second  
b) 9.8 meters per second  
c) 29.4 meters per second  
d) You need to know the mass of the ball to answer the question.  
e) You need to know the height of the building to answer the question.

17. A solar cell is connected to a small light bulb. The solar cell requires 750 joules of radiant energy to produce 250 joules of electrical energy. The small light bulb converts electrical energy into visible light with an efficiency of 40%. What is the overall efficiency of this system?

a) 7.3 %  
b) 9 %  
c) 13 %  
d) 19 %  
e) 33 %

18. Which of the figures below shows a ball with the maximum gravitational potential energy?

a)  
b)  
c)  
d)  
e)
19. Krista pulls a box across a level floor by pulling with a horizontal force of 5 newtons. If the box moves with zero acceleration (that is, with constant velocity), then what is the frictional force on the box?

a) 0 newtons  
b) 2 newtons  
c) 5 newtons  
d) 10 newtons  
e) You cannot answer this question unless you know the mass of the box.

20. A lunar probe has a mass of 2,000 kg on the surface of the Earth. The acceleration of gravity on the surface of the Moon is 1.6 m/s\(^2\). What is the mass of this probe when it is on the surface of the Moon?

a) less than 2,000 kg  
b) 2,000 kg  
c) 3,200 kg  
d) 4,000 kg  
e) 19,600 kg

21. Which jar of olives costs the least per ounce?

a) a jar which costs $1.89 for 15 ounces  
b) a jar which costs $2.09 for 20 ounces  
c) a jar which costs $2.99 for 30 ounces  
d) a jar which costs $3.99 for 50 ounces  
e) a jar which costs $4.99 for 52 ounces

22. The video *The Ring of Truth: Change* showed the Tour de France bike race and discussed how the athletes obtained energy and how it was expended. Each biker consumes 30-32 “jelly donuts” each day. According to the video, about 20 jelly donuts worth of energy (most of the athlete’s fuel) is used for what?

a) To overcome friction in the bike and with the road.  
b) To produce mechanical energy of motion.  
c) To overcome air resistance.  
d) To generate heat in the athlete’s body.  
e) To pump blood.
23. A rock is thrown straight up and reaches a height of 4.9 meters in 1.0 seconds before starting to fall back to the ground. It falls back in the same amount of time, 1.0 seconds. What is its velocity as it hits the ground?

a) 2.45 m/s  
b) 4.9 m/s  
c) 9.8 m/s  
d) 19.6 m/s  
e) None of the above.

24. Betty wants a car that can reach 60 miles/hour (MPH) in 10 seconds. What is the minimum acceleration that the car’s engine must provide in order to give the kind of performance that Betty wants from her car?

a) 1 MPH per second  
b) 2 MPH per second  
c) 6 MPH per second  
d) 10 MPH per second  
e) 12 MPH per second

25. If the pile driver seen in class has a 4 kg mass raised to a height of 0.5 meters, how much work was done to raise the mass? (Ignore any frictional forces.)

a) 2 joules  
b) 4 joules  
c) 12 joules  
d) 19.6 joules  
e) 39.2 joules

26. A force of $5 \times 10^4$ newtons accelerates a sports car with a mass of $2.5 \times 10^3$ kg. What is the acceleration of the car?

a) 0.2 meters/second$^2$  
b) 2 meters/second$^2$  
c) 5 meters/second$^2$  
d) 15 meters/second$^2$  
e) 20 meters/second$^2$
27. An engine produces both 200 joules of mechanical energy and 1800 joules of thermal energy. If no other forms of energy are produced, then what is the efficiency of the engine?

   a) 10 percent
   b) 11 percent
   c) 88 percent
   d) 90 percent
   e) 200 percent

28. What must be the mass of an object that weighs 392 newtons on the surface of the earth?

   a) 10 kg
   b) 20 kg
   c) 30 kg
   d) 38.8 kg
   e) 40 kg

29. A 5 kg block is pushed along the level floor with a force of 4 N. What is the acceleration of the block if the motion is opposed by a constant 2 N frictional force?

   a) 0.4 m/s²
   b) 0.8 m/s²
   c) 1.2 m/s²
   d) 1.5 m/s²
   e) 2.0 m/s²

30. The growth rate chart on page 2 of the exam shows a table of doubling times. If a $100 investment has a 10% growth rate annually how many years would it take for the investment to reach $800?

   a) 3.7 years
   b) 7.3 years
   c) 14.6 years
   d) 21.9 years
   e) 29.2 years